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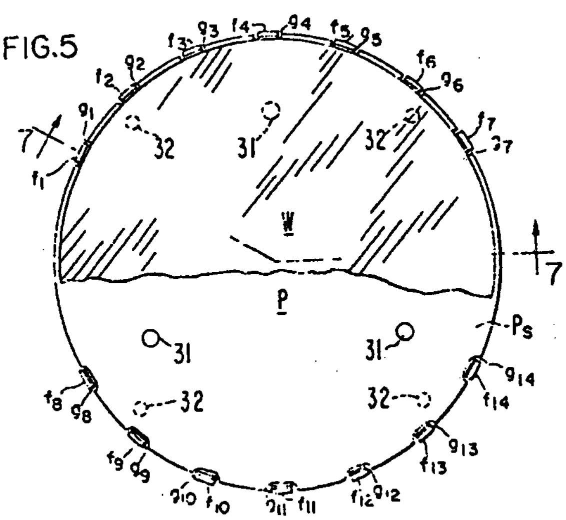
Apparatus for retaining wafers.

A device for releaseably holding a workpiece includes a resilient collet which is pivotally attached to a base. Several fingers for holding the workpiece extend from the collet. The fingers are pivoted by actuating a member which elastically deforms the collet and causes the fingers to pivot from a position for engaging the workpiece to a position for releasing the workpiece and vice-versa. In one application, the base is a platen for supporting a wafer in a semiconductor processing system and a plurality of such platens and a corresponding plurality of the holding devices are arranged around the periphery of the disk. A counterweight ring is attached to the ring-shaped collet to counter-balance the moment generated by the centrifugal force of the wafer pressing against the fingers as the disk is rotated.

FIG.5



EP 0 290 218 A2

Apparatus For Retaining Wafers

This invention relates to an apparatus for accepting, retaining and releasing a workpiece, and in particular, to an apparatus for accepting, retaining and releasing a wafer in a semiconductor processing system.

Prior art devices for holding wafers during processing include a spring-loaded clamping ring as shown, for example, in Faretra, U.S. Patent No. 4,282,924 and commonly assigned to the assignee of the present invention. This clamping apparatus has the disadvantage that the clamping ring presses against the surface of the semiconductor wafer being held in position by the clamping apparatus, thus wasting valuable silicon surface area which is not available for processing. Since such a clamping ring is proud of the wafer surface, sputter contamination of the surface of the wafer during ion implantation may result from energetic ions striking the clamping ring. Further, the sliding surfaces and rubbing springs of such devices tend to generate particles which may contaminate the wafer surface.

In commercially available batch processing ion implantation systems (from, e.g., Eaton, Inc. and Applied Materials, Inc.), a plurality of platens are arranged concentrically around the periphery of a disk and wafers held on the platens are implanted as the disk rotates. In these sytems, the devices used to hold wafers on the platens against the centrifucal force generated by the rotation of the disk include an arcuate bumper on the outer edge of each platen and a spring-driven mechanism to slide the wafers against the bumper. The sliding of a wafer across the platen tends to generate particles on the lower surface of the wafer which impedes thermal contact between the wafer and the platen and which may be transported to contaminate the wafer surface.

The wafer-holding apparatus of the present invention avoids these negative features of prior art holding devices.

Summary of the Invention

A device for releaseably holding a workpiece is disclosed which includes a base, a resilient member attached to the base having a plurality of finger members, and means for moving the finger members to selectably engage or disengage the workpiece by elastically deforming the resilient member.

In one embodiment the finger members are attached to the base by means of a resilient collet having the shape of a closed loop. The collet is elastically deformed to pivot the finger members from a closed position for engaging and thus holding the workpiece to an open position for releasing the workpiece. In a particular embodiment, the base is a platen for holding a flat workpiece. When the fingers are in the open position, the workpiece may be placed on or removed from the platen without contacting the finger members. When the fingers are in the closed position, they do not contact the top planar surface of the flat workpiece, so that the entire top surface of the workpiece is availale for processing.

In one embodiment, the finger members are an integral part of the resilient collet and the collet is attached to the platen by engaging an annular elastomeric ring fixed to the platen. In one preferred embodiment, the surface of the finger members proximate the central axis of the platen are inclined a few degrees with respect to the central axis and are dimensioned so that they do not extend above the surface of the workpiece.

The holding mechanism of the present invention is particularly useful in retaining the workpiece on the platen when the platen is part of a disk in a batch processing apparatus which rotates the disk at high speeds during processing of the workpiece. In such an embodiment, a counterweight is attached to the collet for the purpose of generating a moment equal and opposite to the moment generated by the workpiece pressing against the finger members.

The metallic surfaces of the moving parts of the device are separated by elastomers which practically eliminate generation of particulates.

The invention and its other advantages may be more fully understood by reference to the drawings and accompanying detailed description of the invention.

Brief Description of the Drawings

FIG. 1 shows a simplified schematic cross-sectional diagram of an end station for a batch processing ion implantation system.

FIG. 2 shows a partial cut-away perspective view of an implant chamber.

FIG. 3 shows a partially cut-away view of a transfer chamber for the implant chamber of FIG. 2.

FIG. 4 shows a side view of the wafer loading station in the transfer chamber of FIG. 3.

FIG. 5 shows a top view of a platen P and the wafer-retaining apparatus of the present invention.

FIG. 6 shows a top view of the collet connecting the fingers shown in FIG. 5.

FIG. 7 shows a cross-sectional view along the line 3-3 of FIG. 5.

FIG. 8 shows an expanded scale cross-sectional view of region A of FIG. 7.

FIG. 9 shows another embodiment of the invention for releaseably holding a workpiece.

FIG. 1 shows a simplified schematic cross-sectional diagram of an end station 1 for a batch processing ion implantation system which employs the wafer-holding device (not shown in FIG. 1) of the present invention. End station 1 includes a rotatable disk 2 mounted at its center to drive shaft 5 of spin drive motor 6 which rotates drive shaft 5 about its spin axis D. Spin drive motor 6 and drive shaft 5 are contained in housing 4 which extends through housing 12 to the exterior of vacuum chamber 11. Power line C provides external electric power to spin drive motor 6. Disk 2 is shown in its generally vertical implant orientation in FIG. 1. Disk 2 includes a peripheral conical ring 2a having a selected small base angle B, for example 7°. A plurality of semiconductor wafers W are retained on a corresponding plurality of platens P mounted on ring 2a by the wafer-holding device of the present invention. The surface of each platen P is flat and each platen is partially recessed in ring 2a and attached thereto. As explained below, during operation of the system, each wafer W is forced against its corresponding platen on peripheral conical ring 2a by the component of centrifugal force normal to the surface of the wafer generated by rotation of disk 2 on drive shaft 5.

If desired, drive shaft 5 may include a rotary vacuum feedthrough 8. Fluid lines J and K extend from outside vacuum chamber 11 via housing 4 to rotary feedthrough 8. A first fluid, typically water, for cooling the platens P flows from fluid line J through feedthrough 8 to channels (not shown) in disk 2 which extend from vacuum feedthrough 8 to the platens P. Fluid line K provides a second selected fluid, typically gas, via feedthrough 8 to other channels (not shown) in disk 2 and platens P which carry the selected gas to the back surface of wafers W which are held against platens P. The gas provided between a platen P and a wafer W enhances the cooling of wafer W when wafer W is subjected to the heat caused by the impact of ion beam 14 on the surface of wafer W. Ion beam 14 is formed in an ion source (not shown) and is passed through appropriate mass analysis and ion optical elements (not shown) before being applied to wafers W. Vacuum pump 7 is coupled through isolation valve 9 to vacuum implant chamber 11 defined by housing 12. Vacuum pump 7 serves to evacuate vacuum chamber 11 prior to implantation of wafers W.

FIG. 2 shows a partial cut-away perspective view of implant chamber 11 with disk 2 in horizontal position. Disk 2 is rotated about axis A by flip drive motor 14 and associated linkage (not shown) from the position shown in FIG. 2 to the implant position shown in FIG. 1. Scan drive motor 16 and associated linkage (not shown) reciprocate disk 2 in a plane approximately perpendicular to ion beam 14 when disk 2 is oriented for implantation as shown in FIG. 1. Motors 14 and and 16 are mounted exteriorly of chamber 11.

In operation, a wafer in loadlock 29 (FIG. 1) is conveyed to a selected platen P on disk 2a by means of transfer arm 22 located in transfer chamber 24 as is explained in more detail in connection with FIG. 3.

FIG. 3 shows a partially schematic plan view of transfer chamber 24 and elevator chamber 20 of loadlock 29. Cassettes 10 holding wafers W are placed in elevator chamber 20 of loadlock 29 via loading chambers not shown in FIG. 2 and which are not pertinent to the present invention. The details of loadlock 29 are provided in copending U.S. Patent Application Serial No. 856,814, entitled "Wafer Transfer System", assigned to the assignee of the present invention which is incorporated herein by reference. Wafers W are removed from a selected cassette holder 10 one at a time by wafer transfer arm 22.

Transfer vacuum chamber 24 opens off implant chamber 11 and is defined by housing 51. Chamber 24 is connected to a vacuum pumping system (not shown) for evacuation thereof. Transfer arm 22 is located in chamber 24 and is supported and operated by a transfer drive system which includes a drive assembly 54 which supports and drives transfer arm 22. Drive assembly 54 and arm 22 attached thereto are laterally moveable along the Y axis shown in FIG. 1. Drive assembly 54 is moveable along the Y axis under the control of drive motor 56 positioned outside chamber 24 and a lead screw 58 so that drive assembly 54 and arm 22 mounted thereon can be positioned opposite a selected cassette 10. Additional details concerning the operation of transfer arm 22 are provided in the above-referenced copending U.S. Patent Application. Once positioned opposite a selected cassette, transfer arm 22 is extended through opening 48 into cassette 10 beneath a selected wafer and then cassette 10 is lowered by an elevator mechanism (not shown) a selected distance so that the selected wafer is transferred to transfer arm 22. Transfer arm 22 is then withdrawn from cassette 10.

In order to transfer the wafer W on arm 22 to a selected platen P on conical ring 2a, disk 2 is rotated about axis A and about axis D so that the selected platen P is horizontal and located above

biasing the fingers f_1 through f_4 inward to the closed position for engaging a wafer shown in FIG. 8. In one embodiment α is 5°.

In operation, the finger f is pivoted counter-clockwise, as indicated by arrows C, about a virtual pivot arc P_a to an open position for allowing the wafer W to be lowered onto platen P by prongs 30 (FIG. 4) or to be removed from platen P by prongs 30 without contacting finger f.

The pivoting of finger f to the open position is accomplished by air cylinder 50 (FIGS. 4 and 8), or other means, driving prongs 32 through openings (not shown) in ring 2a and against the bottom side of counterweight ring 53, which causes counterweight ring 53 to move upward, elastically deforming thin resilient portion 41a of collet 41 until it is stopped by pressing against elastomer 43. Deforming the spring portion 41a causes a type of "oil-can" action in the spring portion similar to the action of a Bellville spring washer which yields almost constant spring force over the full stroke range. Rate characteristics may be selected by selecting the geometry of the collet. This elastic deformation causes finger f to pivot about virtual pivot arc P_a. The edge E of collet 41 pressed into groove 47 in elastomer 43 acts as a pivot in a sensitive gravimetric scale where finger f is the balance beam. The pivot arc P_a is a virtual extension of groove 47.

In operation, air cylinder 50 drives all four prongs 32 (FIG. 4) against ring 53 simultaneously. Since counterweight ring 53 is substantially more rigid than the resilient portion 41a of collet 41, the four actuating prongs 32, which are spaced 90° apart beneath counterweight ring 53, simultaneously pivot all of the fingers f_1 through f_4 when prongs 32 are driven against counterweight ring 53. When actuating prongs 37 are lowered by air cylinder 50, the elastically deformed resilient portion 41a elastically restores itself. Air cylinder 50 simultaneously drives actuating prongs 32 and lifting prongs 30. These prongs are dimensioned relative to platen P so that prongs 32 engage counterweight ring 53 to drive collet portion 41a against elastomeric stop 43 and thus pivot fingers f_1 through f_4 to the open position before lifting prongs 30 emerge above the top surface of platen P. Air cylinder 50 then continues to drive lifting prongs 30 above the top surface of platen P while actuating prongs 32 continue to press on counterweight ring 53 by means of spring compliance. The operation of air cylinder 50 is controlled by a controller (not shown).

In operation, when the implant system is in the implant orientation (FIG. 2), spin drive motor 6 typically spins disk 2 at a rate on the order of 1000 rev min, which generates a centrifugal force having a component normal to the planar surface of wafer W and a component parallel to the planar surface of wafer W. In the operating environment described above, accelerations of approximately 500g are generated near the periphery of portion 2a of the spinning disk 2, and the fingers f must remain in the closed position even in this extreme environment.

The component normal to the surface of wafer W presses wafer W against platen P. The component parallel to the surface of wafer W causes wafer W to press outwardly against those fingers near the outer edge of portion 2a of disk 2. When wafer W presses outwardly against a selected finger f (FIG. 8), the force generated by the wafer has a lever arm of length L_1.

The counterweight ring 53 is subject to the same centrifugal forces as wafer W. The slender profile of aluminum counterweight 53 allows ring 53 to elastically deform under high g loads to an oval shape. Thus, as wafer W presses outward against finger f, the elastomeric interface 61 on counterweight ring 53 also presses against finger f. Molded elastomeric ring 61 recessed in the outer edge of counterweight ring 53 provides a soft contact surface between counterweight ring 53 and finger f. The force exerted on finger f by elastomeric interface 61 has a lever arm of length L_2. The weight of counterweight ring 53 is selected so that the rotational moment about pivot arc P_a generated by wafer W is approximately balanced by the opposing rotational moment generated by counterweight ring 53.

Finger f shown in FIG. 8 extends slightly above the surface of the wafer. In another embodiment the finger f is dimensioned so that it extends only to the top surface of wafer W. The phantom line 53 in FIG. 8 indicates the contour of a finger f which does not extend above the surface of wafer W. This contour is advantageous for reducing the sputter of the wafer surface caused by energetic ions striking fingers f.

It should also be noted that inside face, f_a of finger f is angled at a few degrees, typically 3-4°, from the normal to the flat surface of platen P. This provides a good contact with the semicircular edge of a typical wafer and provides a small component of the force of finger f pressing against wafer W normal to platen P, which also tends to hold wafer W on platen P. In the embodiment shown in FIG. 8, the inside face f_a is also curved (in a plane perpendicular to the plane of FIG. 8) to match the curved circumferential edge of the wafer, thus spreading the load and reducing stress on the wafer. Finger f is also slightly tapered to reduce mass. In one embodiment (not shown) the inside surface f_a is coated with PTFE or other suitable material to prevent wafer W from contacting the metal of finger f, thus reducing particle generation

and improving the grip of finger f.

FIG. 9 shows another embodiment of the invention suitable for use in a device which is not part of a rotating system. In the embodiment of FIG. 9, collet 41 is attached to base B in the same way that collet 41 is attached to platen P in FIG. 8. Wafer W in FIG. 9 is supported by notches fg in fingers f and does not contact base B. Fingers f are moved to an open position by air cylinder 72 (or other suitable driving means) which drives a plurality of prongs 75 against annular ring 71. Elastomeric ring 73 is molded on ring 71 and elastically deforms resilient portion 41a of collet 41 when air cylinder 72 drives prongs 75 and ring 71 upward.

The apparatus described above for releaseably retaining a wafer on a platen has several other advantages over prior art clamping devices.

No surface area of the wafer W is contacted by the wafer retaining apparatus, so that all of the surface area of the wafer is available for the production of semiconductor devices.

Since the wafer is lowered vertically onto the platen and then held there by the retaining fingers, wafer sliding against the platen, which may cause contamination by generating particulates, is virtually eliminated. None of the moving parts of the apparatus slide or rub against the wafer.

All metal parts of the wafer retaining apparatus snap together by means of elastomeric interfaces, eliminating metal to metal contact, which generates particles, and also eliminating metal fasteners such as screws. In general, assuming at least 3 fingers contacting the wafer along an arc greater than 180°, the sum of the forces on the wafer exerted by the fingers (and vice-versa) is independent of the number of fingers contacting the edge of the wafer. Thus, by increasing the number of fingers, the force exerted by each finger on the wafer is reduced, which reduces wafer breakage. If a finger is positioned opposite a wafer flat, the holding device remains in equilibrium.

Finally, the design is intrinsically safe. Wafer W will be retained on the rotating platens for the duration of the implant process even if the spring portion of the collet breaks or if the counterweight ring 53 is no longer retained by elastomeric projections 57.

The above embodiments are intended to be exemplary and not limiting, and in view of the above disclosure, many modifications and substitutions will be obvious to one of average skill without departing from the scope of the invention. For example, while the resilient member 41a in FIGS. 8 and 9 is in the shape of a continuous generally annular ring angled slightly downward from outer edge to inner edge, in other embodiments the resilient member may be given other shapes to better accommodate the shape of the workpiece. For example, the resilient member 41a may be an oval loop or square loop. In the embodiment shown, the resilient member 41 forms a simple closed loop; but if desired, the resilient member may comprise more than one disjoint resilient section, each section connecting a plurality of fingers, with a separate means for selectively elastically deforming each resilient section to move the fingers attached thereto into and out of engagement with a workpiece. It should also be clear that the invention may be used for releaseably retaining any workpiece and that the workpiece need not be shaped like a disk. The invention may also be employed to retain wafers in conjunction with many different semiconductor processes in addition to ion implantation.

Claims

1. A device for releaseably holding a workpiece, said device comprising:

a base;

a resilient member having a plurality of finger members extending therefrom, each of said finger members being separated by a portion of said resilient member, said resilient member being attached to said base; and

means for selectably moving said finger members into and out of engagement with said workpiece, said means for moving including means for elastically deforming said resilient member to move said finger members.

2. A device as in claim 1 wherein said resilient member is pivotally attached to said base, elastic deformation of said resilient member by said means for deforming causing said finger members to pivot.

3. A device as in claim 1 wherein said finger members are coated with a material selected to reduce particle generation or to improve the grip of said fingers.

4. A device as in claim 1 wherein said resilient member is a simple closed loop.

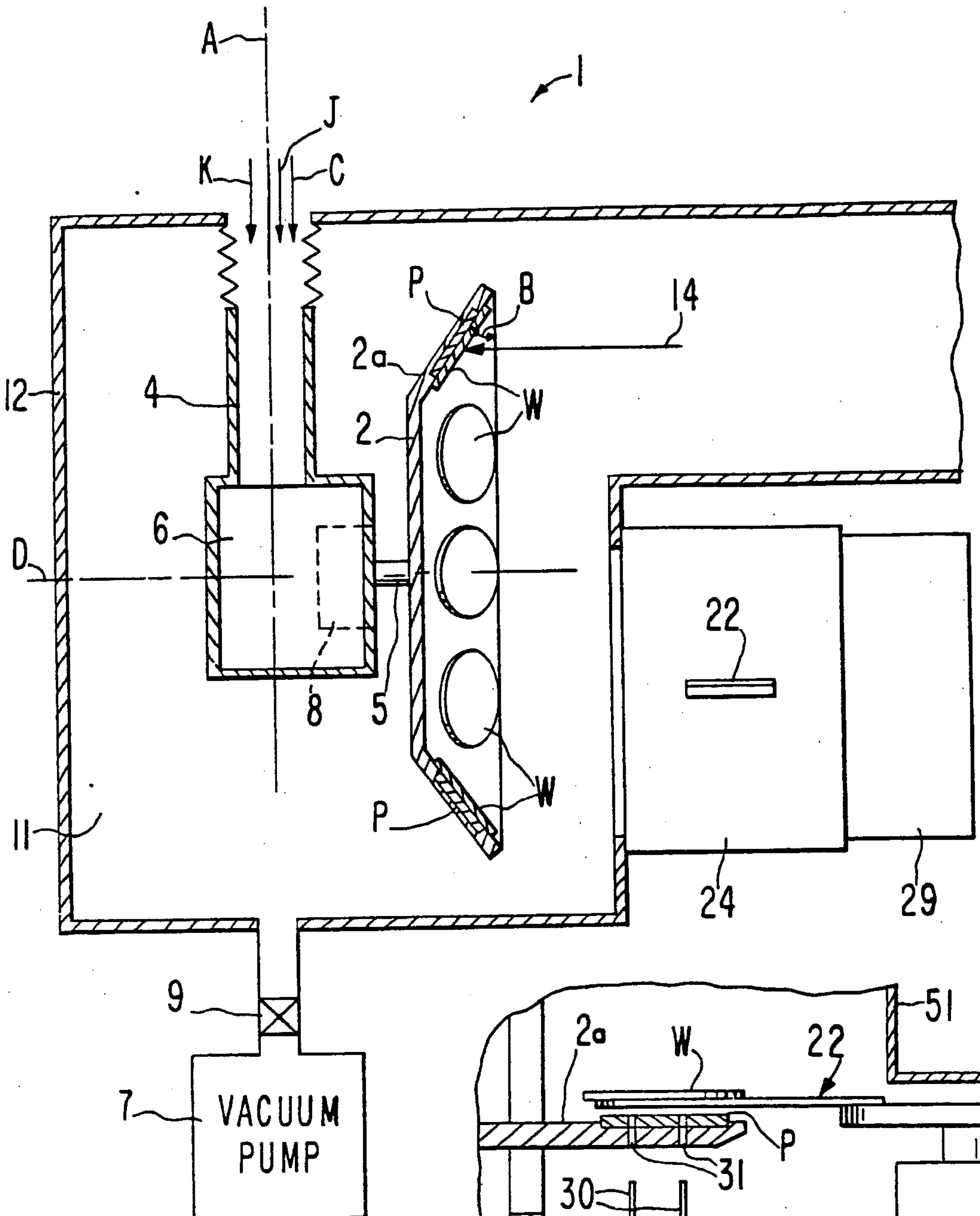
5. A device as in claim 4 wherein said simple closed loop comprises a conical ring.

6. A device as in claim 4 wherein said simple closed loop comprises a generally annular ring.

7. A device as in claim 1 or claim 2 wherein said base comprises means for supporting said workpiece.

8. A device as in claim 7 wherein said workpiece is flat and wherein said means for supporting said workpiece comprises a platen having a flat surface.

FIG.1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B
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D
8
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11
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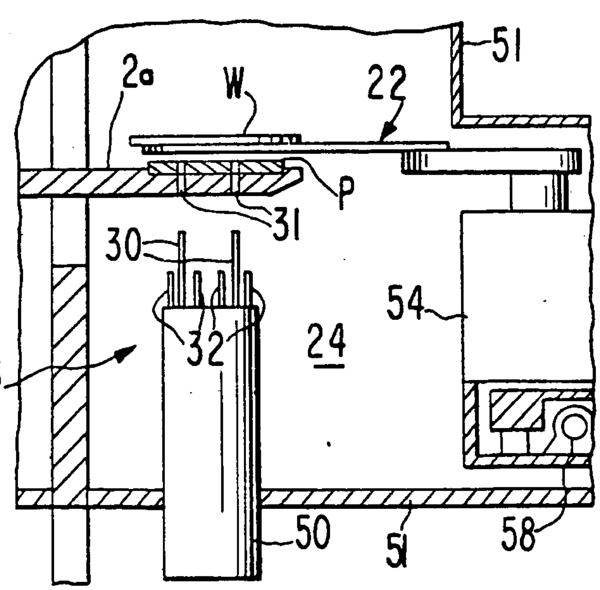
29
9
7
VACUUM PUMP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P
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FIG.4

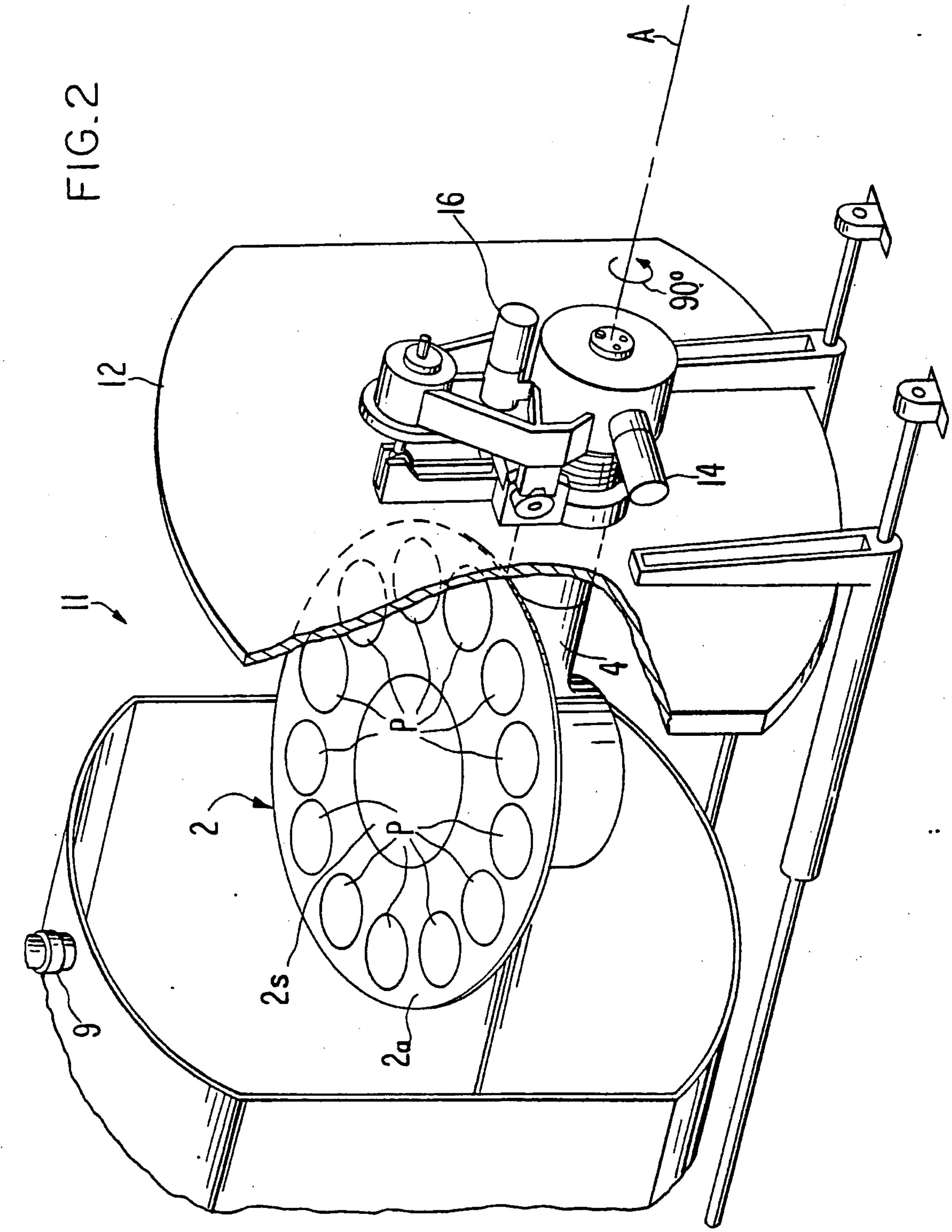

FIG.2

FIG.3

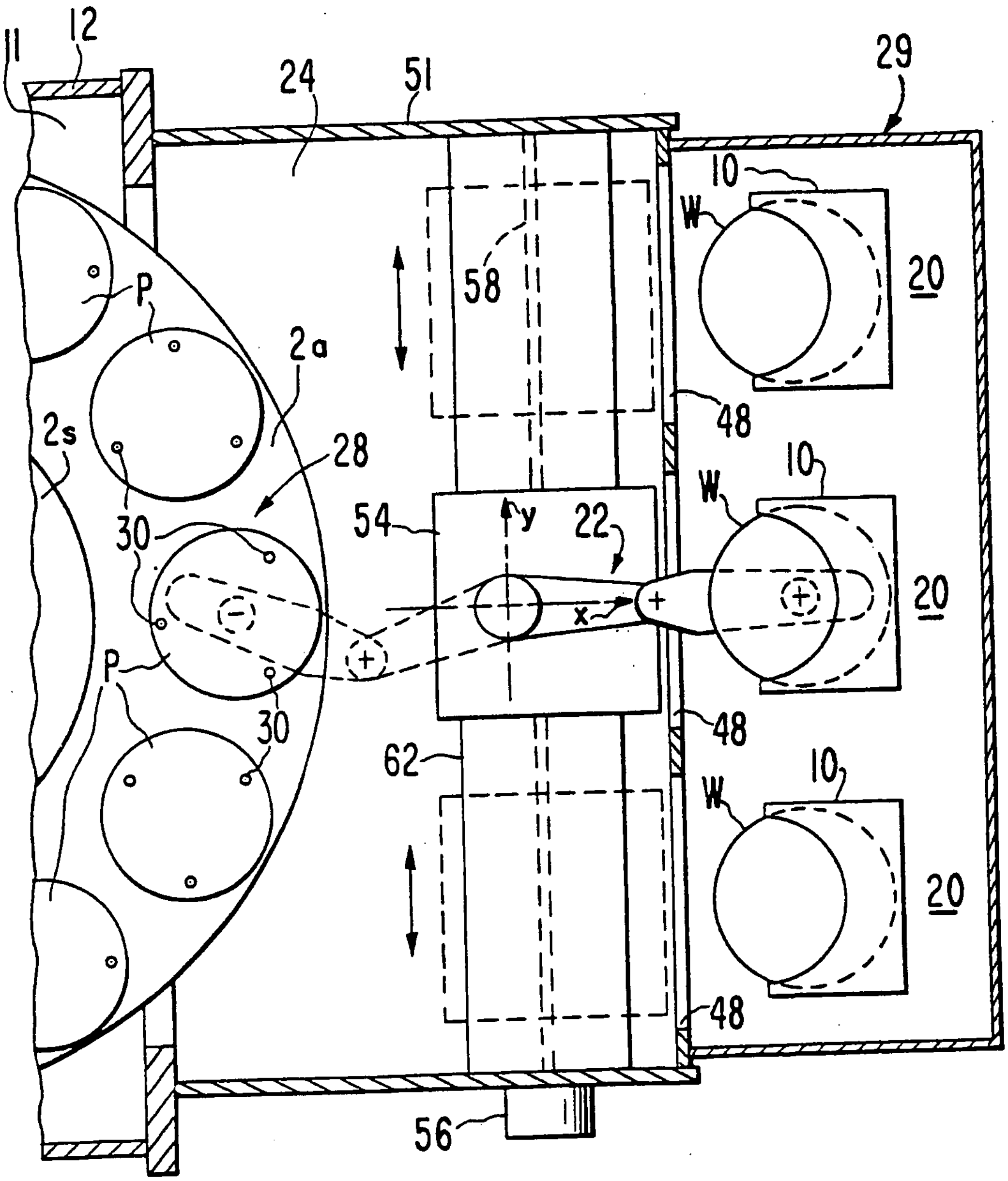
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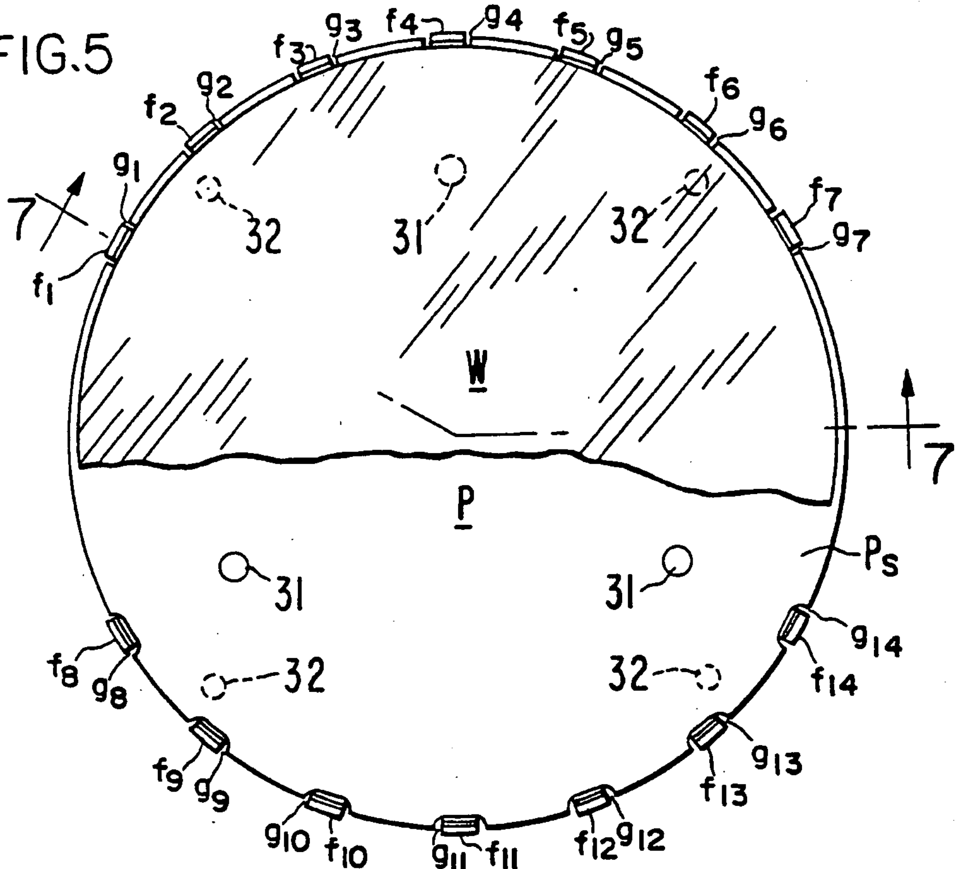
FIG.5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7
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31
32
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32
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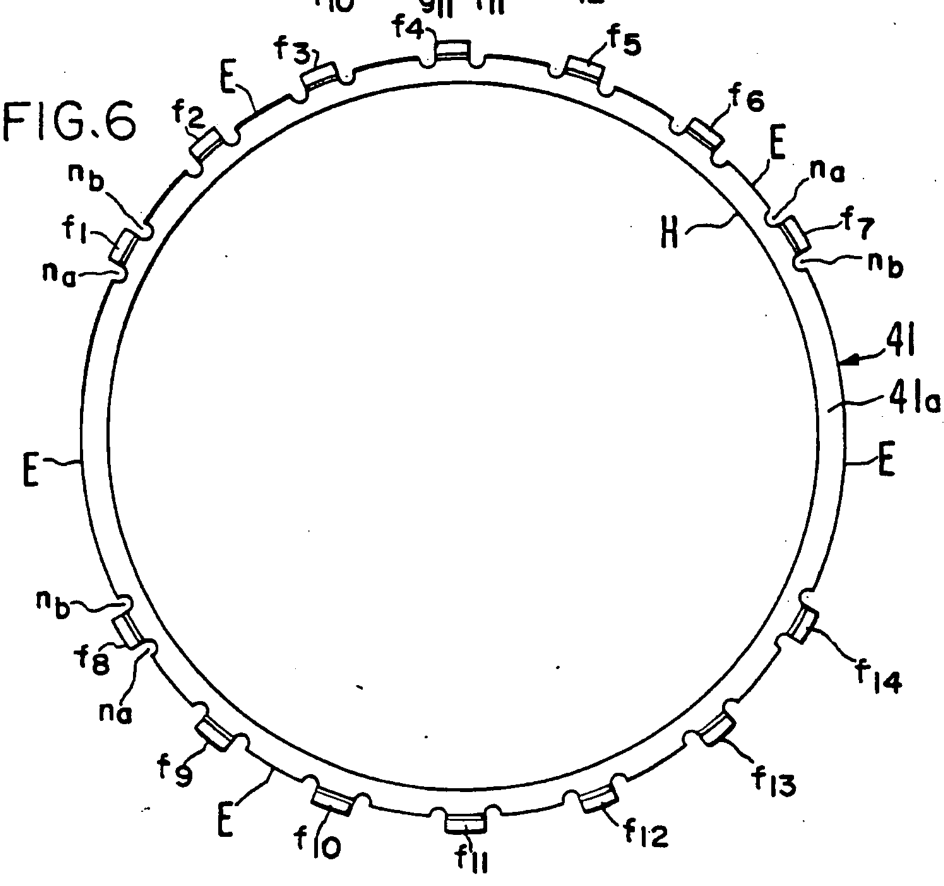
FIG.6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na
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41
41a
E
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f8 f9 f10 f11 f12 f13 f14

FIG.7

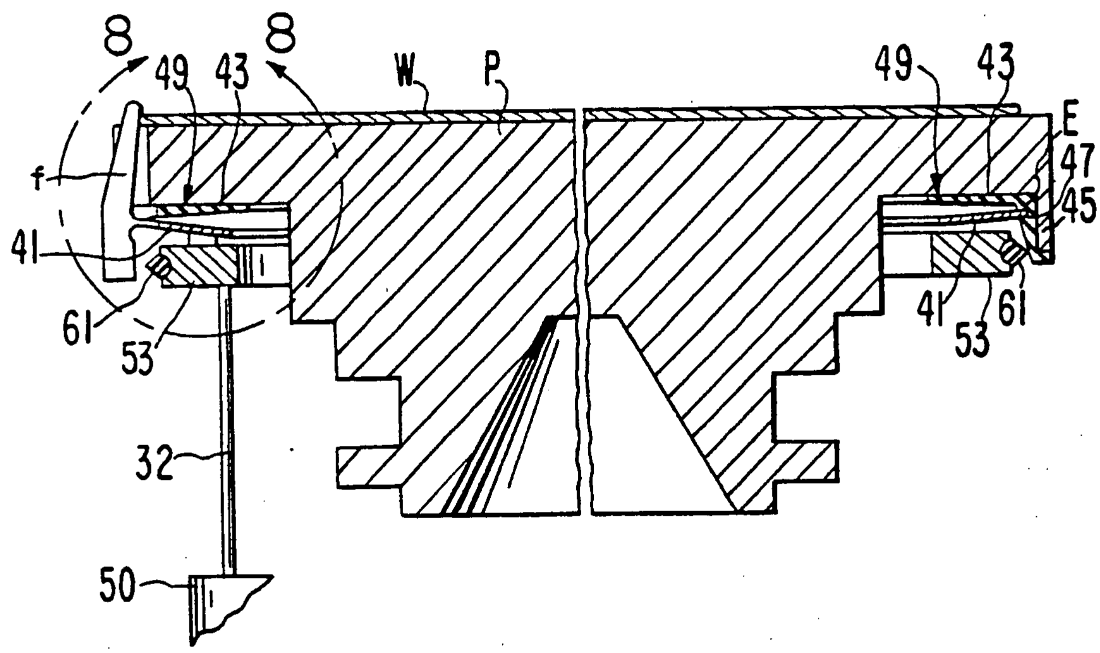
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FIG.8

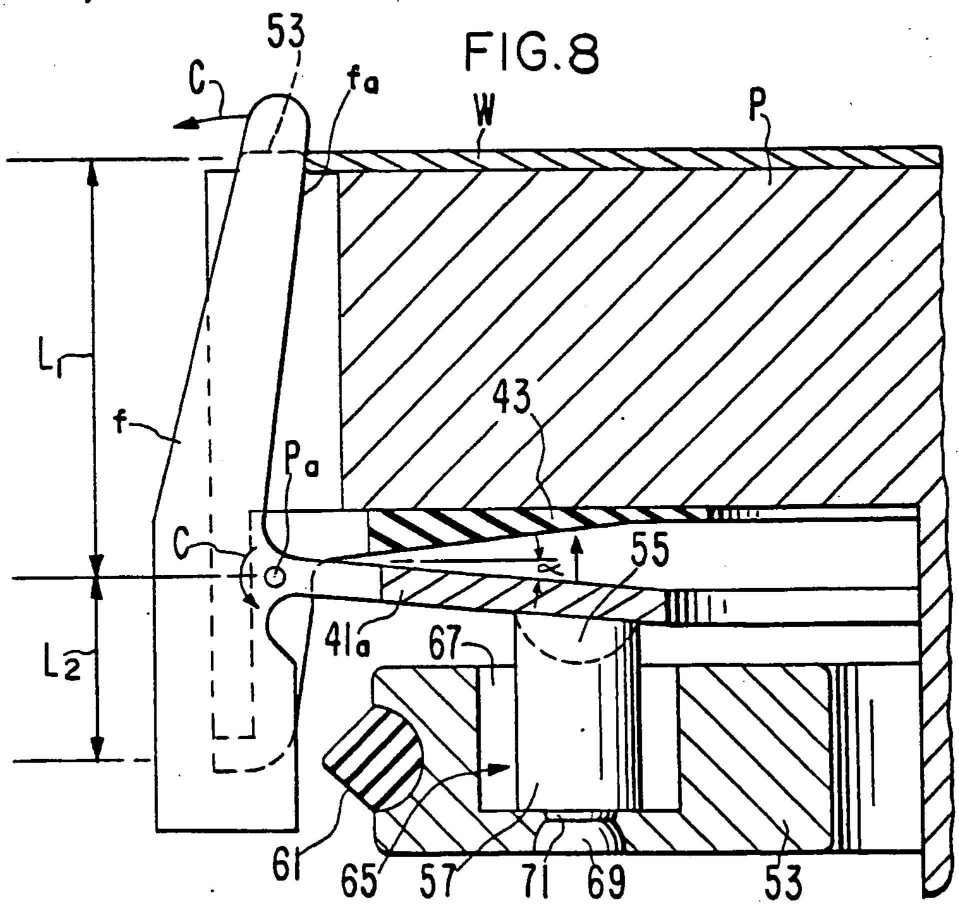
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FIG.9